LANDTECHNIK 73(5), 2018, 162–175
DOI:10.15150/lt.2018.3193

LANDTECHNIK
AGRICULTURAL ENGINEERING

Economic evaluation of selected animal welfare measures in pig farming from a single farm perspective

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In pig farming, social demand for more animal welfare is a very big issue. Improving housing conditions is in most cases connected with additional costs for the farmer. Against this background it is important for all stakeholders to know the economic effects of animal welfare measures. Based on calculations from single farm perspectives, estimates of the resulting additional costs can be made. In the present contribution, the economic effects of a higher space allowance in the waiting area, in the piglet rearing area and in the fattening barn, also the use of a novel farrowing system where the sow can be crated temporarily and finally the additional feeding of roughage are modeled for a farm with 400 sows with 10,837 fattening pigs sold in a closed system. It turned out that with the exception of the roughage feed considerable additional costs can be expected. The study provides important foundations for the implementation of measures to increase animal welfare standards in pig farming.

Keywords
Economy, Pig farming, Animal welfare measures

Today‘s animal husbandry in Western Europe is characterized by high efficiency. This is the result of decades of developments in animal breeding, animal nutrition and in animal husbandry itself. Increased performance, whilst at the same time reducing production costs, is the primary objective in animal production (Hölscher 2016). Nevertheless, continuing international competitive pressure ensures that structural change is continuing due to efficiency reasons and the results are fewer farms with higher number of animals per farm (Dawkins 2017). According to an assessment by the scientific Advisory Council Agriculture Policy at the Federal Ministry of Food and Agriculture in the report „Ways to socially accepted livestock husbandry“ German livestock farming has come under increasing pressure in social discourse due to the intensification of production and the growth of stock sizes (WBA 2015). Along with the use of antibiotics (European Commission 2005) and nitrate pollution of water by livestock (Conrad 1992) animal welfare is the focus of the discussion (Heise and Theuvsen 2017). Many consumers describe modern housing conditions rather negatively and regard them as less suitable for animals (Isermeyer and Schrader 2003; Schulze et al. 2008). The WBA caused a sensation, calling housing conditions of many livestock animals unsustainable in 2015. Popular criticism has been taken up in particular by the media, animal welfare associations, food retailers and, last but not least, politicians. In all cases it is used as the basis for demands for higher animal welfare standards (WBA 2015). To sum up there is an increasing demand for a fundamental reorientation of animal husbandry in Germany (Spiller et al. 2016).

received 30 July 2018 | accepted 25 September 2018| published 23 October 2018

In response to this increasing pressure, there are several approaches for implementing higher animal welfare standards:

- Label approaches, for example the German „Für mehr Tierschutz“ of the German Animal Welfare Association rely on consumers with a preference for animal welfare products being willing to pay more (Pirsich 2017).
- Sector approaches, for example the German „Initiative Tierwohl“ (ITW) which includes an animal welfare fee paid to the participating farmer. It relies on food retailer payments: for every kilogram sold of pork and sausage, of chicken and of turkey, money is paid in a fund by the participating players (ITW 2018).
- Enforcing animal welfare measures, subsidized or – without financial compensation – through legislation (Deimel et al. 2010).

All alternatives usually entail an increase in production costs (Spandau 2015; Hölscher 2016), in particular due to investments (rebuilding measures), higher direct costs (e. g. feed, energy), increased workload (e. g. due to additional roughage feed) or changes in animal performance (e. g. higher suckling piglet losses, lower daily weight gains). The cost effects depend both on the measure (e. g. higher space available, free movement pen) and on the farming conditions (Weiss 2013).

Animal welfare standards which are higher than legal requirements but without simultaneously rising prices or providing compensation (such as in the “Initiative Tierwohl”) often lead to a loss of profit and thus represent a threat to the future viability of agricultural farms (Spandau 2015). A conflict therefore exists between the goal of profitable production whilst still under considerable competitive pressure and that of higher animal welfare standards (Dawkins 2017; Isermeyer and Schrader 2003). Any solution to this conflict of goals requires subsidies, compensation payments (Mann 2004; Weiss 2013) or higher prices to the producer (Spandau 2015). To estimate the financial resources required for compensating the additional costs of higher animal welfare standards, detailed analyzes are necessary, which in turn provide information about the economic effects of animal welfare measures. So far, however, such analyzes are only available sporadically. Therefore, in this paper, based on an exemplary farm, which produces pigs in a closed system, various animal welfare measures are examined for their associated costs. The additional costs in several scenarios involving differing space in the waiting area, in the weaner accommodation and the fattening stable, also offering additional roughage as well as the conversion of conventional farrowing pens with farrowing crates to free movement pens are calculated. The results provide a differentiated assessment of the financial effects of animal welfare measures and thereby could support farmers’ decisions and policy.

Data basis

On the basis of direct cost-free performance as well as direct and labor cost-free performance, various animal welfare measures scenarios are examined and their additional costs determined. Direct cost-free performance results from the revenues of a production process minus the costs directly attributable to it. To determine direct and labor cost-free performance, fixed and variable operating costs are deducted. Direct and labor cost-free performance serves to cover the remaining fixed costs such as area, building, legal and general costs (Schroers and Sauer 2011).

In order to determine the additional costs, direct cost-free performance and direct and labor cost-free performance for an initial situation are calculated. On this basis, the corresponding key figures for various scenarios involving animal welfare measures are evaluated. In addition any change in building costs is indicated, where it is relevant. The difference between the direct cost-free performance (or direct and labor cost-free performance) plus optional building costs provides the baseline scenario which then informs each respective scenario with the amount of compensation necessary for the implementation of higher animal welfare standards.

The calculations are based on a typical farm with perennial mean values from the financial years 2013/2014 to 2016/2017 as well as standard values, such as the Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL 2016). Additional expert interviews as part of a qualitative preliminary study will be used to estimate the cost effects of animal welfare measures. Experts from the chambers of agriculture and consultants for pig production were therefore consulted. A typical farm reflects a style of pig farming in a specific region. It indicates a typical farm size, combination of branches, the predominant production system, labor stocking and the holding of owned and leased land for that region (Verhaagh et al. 2018).

The typical farm considered is located in the region Weser-Ems and has 400 sows with 10,837 sold fattening pigs in the closed system. There are 100 farrowing places in the farrowing unit divided into five sections of 19 sows each. In each section there is reserve pen. The farrowing pens measure 4.75 m^2. There are a total of 209 places for sows in the waiting area; for 400 sows 190 places are necessary. The places in the waiting area are divided into eleven pens of 19 sows each and one pen serves as a reserve pen. Each sow has a total of 2.3 m^2 space (legal minimum standard: 2.25 m^2) (TierSchNutztV 2006). The piglet rearing area consists of 1,938 places of 0.35 m^2 (legal minimum: 0.35 m^2) for each piglet. The places are separated into 51 pens, which are housed in eight sections. The liquid manure costs will be 3.66 €/m^3 for an annual liquid manure of six cubic meters per sow including piglet rearing (Agri Benchmark 2016). The payment for the manager and well-trained employees is set at 17.50 €/hour. In the baseline scenario 12 labor hours per sow per year were presumed. The fattening stable comprises 3,990 fattening places (FP), divided into 210 pens of 19 pigs each. The space available per fattening pig is 0.75 m^2. Per fattening place and year about 1.5 m^3 liquid manure is assumed.

On average in 2.34 farrowings 33.9 piglets per year are born to each sow. After deduction of the piglet (15.5 %) and rearing losses (2.6 %) there remain 27.9 piglets per sow and year reared, which are moved into the fattening barn when weighing 30 kg. With losses of 3.0 % 10.837 slaughter pigs with a live weight of 121.5 kg are sold per year. The carcass yield is 79 % which results in a slaughter weight of 96.0 kg. The fattening period including vacancy periods is 130.5 days; hence 2.8 fattening periods per year are possible. The daily gains are 817.9 g per day; the feed conversion thus corresponds to 1 : 2.82.

Prices, costs as well as biological performance parameters are extracted from „agri benchmark pig“ (Agri Benchmark 2016). The calculations are stated at their net value. The building costs were estimated using the "KTBL Baukost" application. Investment costs from 2015 (KTBL o. J.) were divided by two in order to approximately represent past depreciation on old buildings and not-yet depreciated newer building parts. From the total amount resulting, 8.5 % is assumed as annual building costs. Necessary reconstruction work costs are calculated according to Pflanz and Asse (2012); there is also 8.5 % of the total amount used to determine the annual costs.

Scenarios

In the following paragraphs, the scenarios considered are presented. In Scenario 1, standard pens with farrowing crate with 4.75 m^2 were converted to farrowing pens with a floor area of 6 m^2 and crates which could be opened for keeping the sow loose. For this purpose the farrowing crates were rebuilt so that they can be used for as temporary fixation for the sow. The troughs, the floor and the old pen walls were largely reused in the conversion. The sow stock size had to be reduced due to the larger pens because the conversion of the farrowing pens reduced the number of farrowing places from 100 to 80. Instead of 20 pens per section, only 16 farrowing pens are now possible – each group of sows includes 15 sows in order to provide one reserve pen per section for foster mothers. The weekly farrowing rhythm with 28 days of weaning can be maintained. Based on expert estimates, an increase in suckling piglet losses to 18 % and an additional labor hour per year were set.

Scenario 2 includes 10 %, 20 % or 40 % additional space allowance in the waiting area, in the piglet rearing area and in the fattening stable. It was therefore calculated how many sows piglets and fattening pigs could be kept in the three space options under given conditions for each pen. Based on the number of sows that could still be kept after increasing the area per animal in the waiting area, the possible number of sows per group and hence the maximum sow population was calculated. The number of sow places is divided by eleven groups, since ten sow groups plus one empty group are stabled in the waiting area every week. From the number of sows per group and the number of sow groups (21 groups at 28 days nursing time), the sow herd size can be determined (Meyer und Tölle 2007).

Working time requirement in piglet production remained the same with 10 % of additional space overall, however with 20 % additional space, a 10 % reduction of the total working time requirement is assumed (Leuer 2013) compared to the starting situation of 5 % and 40 % additional space. When assessing the impact of higher space availability in the piglet rearing area, the procedure was similar to the observation in the waiting area. Based on the legal standard, the number of animals which can be kept per pen with the appropriate place variations was calculated. Multiplied by the number of rearing periods per place, this results in the maximum number of piglets that can be raised there annually. Dividing the number of weaned piglets per sow and year gives the ultimate possible sow herd size with a higher space allowance in the piglet rearing area. Since overcrowding needs to be avoided, the maximum number of sows is calculated on the basis of the weaned piglets and not those raised. With a 20 % additional space allowance, the working time requirement is reduced by 0.6 labor hours per sow and year and with a 40 % additional space allowance by 1.2 labor hours per sow and year.

Also for the pig fattening area, it must first be determined, how many animals can be kept with 10 %, 20 % or 40 % additional space allowance for each pen. Based on the lost places, the direct cost-free performance loss per pen is determined. The additional costs per place can be calculated by dividing the direct cost-free performance loss by the number of animals left after reducing the number of places. The working time requirement per place (0.9 labor hours) is reduced by 5 % with a 20 % additional space allowance and 10 % with a 40 % additional space allowance.

Scenario 3 provides roughage feeding as manipulable material in the waiting area, in the piglet rearing and in the pig fattening areas. The costs are calculated taking into account the initial conditions in the baseline scenario. In sow husbandry, the Düsser Wühlturm (DWT) with space requirement of 0.38 m^2 is used in the waiting area. The following costs are estimated (Janssen 2013; Stalljohann 2014; KTBL 2016):

- Investment costs: 230 €/DWT; annual costs: 29.90 €/DWT; working time requirement: 2 labor hours/DWT and year; consumption of straw: 200 g/day and animal or 0.4 decitonne per sow and year (85 days · 2.34 litters); costs for straw: 12 €/deci-tonne or 4.80 €/sow and year.

In the piglet rearing area a rack is installed, which is less massive and does not reduce the space requirement. Since the rack is open on the sides and to the front, it is assumed that one rack per pen is sufficient for up to 40 animals (Janssen 2013):

- Investment costs: 80 €/rack; annual cost: 10.40 €; working time requirement: 1 labor hour per rack and year; consumption of straw: 20 g/day and animal or 0.065 deci-tonne per rearing place and year (54 days · 5.98 rearing periods); cost of straw: 12 € per deci-tonne or 0.78 € per piglet.

In the pig fattening area a similar rack as in the piglet rearing area is installed. The following costs are assumed (Janssen 2013):

- Investment costs: 80 €/rack; annual costs: 10.40 €; working time requirement: 1 labor hour/rack and year; consumption of straw: 50g/day and animal or 0.157 deci-tonne per FP and year (112 days · 2.8 fattening periods); costs of straw: 12 € per deci-tonne or 1.88 € per fattening pig.

No changes in veterinary costs and animal performance are included in the calculations, although in the qualitative preliminary study the experts indicated positive effects of animal welfare measures on animal health and behavior.

Results

Baseline

For the piglets produced, despite fattening own piglets in a closed system, a market price (perennial average) is set in order to be able to carry out a separate analysis of the branches. Piglet production generates revenues of 1,459.62 € per sow and year (Table 1). The revenues are offset by variable costs for feed, veterinary care, water, energy, etc. of 1,084.39 €/sow and year, so that a direct cost-free performance of 375.23 € or – after deduction of the liquid manure costs of 21.94 €/sow and year – from € 353.29 €/sow and year is achieved. The operating costs are 210 € and the building costs 180.42 € per sow and year. After deducting all costs, this results in a negative operating result of -37.13 €/sow and year, or -14,852.29 €/year.

Table 1: Operating result piglet production

	€/sow	€/year
Total performance	1,459.62	583,849.20
Direct costs	1,084.39	433,756.68
Direct cost-free performance	375.23	150,092.52
Liquid manure costs	21.94	8,776.00
Direct cost-free performance after liquid manure costs	353.29	141,316.52
Operating costs	210.00	84,000.00
Direct and labor cost-free performance after liquid manure costs	143.29	57,316.52
Building costs	180.42	72,168.81
Operating result after liquid manure costs	**-37.13**	**-14,852.29**

Source: calculations according to AGRI BENCHMARK (2016)

The direct cost-free performance in the pig fattening amounts to 32.19 €/animal or 90.12 €/fattening place. There are costs of 116.61 €/animal, which are offset by revenues of 148.80 € per fattening pig (Table 2). The costs of transporting the liquid manure amounts to 5.84 € per fattening place and year or 23,281.65 € per year. In addition, there are the operating costs (0.9 labor hours per fattening place MP · 17.5 €/hour) (Agri Benchmark 2016) and building costs. For pig fattening, this results in a positive operating result of 49.68 €/MP or 198.225,95 €/year.

Table 2: Operating result pig fattening

Pig fattening				€/FP/year	€/year
Revenues	€/pig	148.80	Dcfp a.l.	84.29	336,308.88
Costs	€/pig	116.61	Labor costs	15.75	62,842.50
Direct costs	€/pig	32.19	Dlcfp a.l.	68.54	273,466.38
Direct costs	€/FP	90.12	Building costs	18.86	75,240.43
Liquid manure costs	€/FP	5.84	Operating result a.l.	49.68	198,225.95

a. l.= after liquid manure costs, dcfp = direct cost-free performance, dlcfp = direct and labor cost-free performance
Source: calculations according to Agri Benchmark (2016)

Implementation of animal welfare measures

Scenario 1

The economic effects of converting to a free-movement pen (Scenario 1) are shown in Table 3. The number of sows, which was reduced to 315 animals due to the higher space requirement in the free-movement pens, causes a difference in the direct cost-free performance after liquid manure costs compared to the baseline scenario of -42,332.40 €. This results in a reduction of the direct cost-free performance of -134.39 €/sow (or -4.96 €/piglet). After deducting the labor costs, the direct cost-free performance difference is 29,994.9 or 95.22 € per sow (or -3.73 €/piglet) compared to the baseline scenario. For the building costs, there are annual costs of 6,800 € for the conversion of the 80 farrowing places. Due to the reduction of sow herd size and the necessary reconstruction work, the building costs increase to 250.69 €/sow. The additional costs per sow amount to 70.27 €. As already mentioned in the baseline scenario, the negative operating branch result increases again to 234.23 €/sow and year in scenario 1.

Table 3: Economic effects for scenario 1

Stock size		**400 (baseline scenario)**	**315 (scenario 1)**
Performance	€/year	583,849.20	447,478.61
Costs	€/year	433,756.68	341,583.39
Dcfp	€/year	150,092.52	105,895.22
Liquid manure costs	€/year	8,776.00	6,911.10
Dcfp a.l.	€/year	141,316.52	98,984.12
Difference	€/year		-42,332.40
Reduction dcfp/sow	**€/sow**		**-134.39**
Operating costs	€/year	84,000.00	71,662.50
Dlcfp a.l.	€/year	57,316.52	27,321.62
Difference	€/year		-29,994.90
Reduction dlcfp/sow	**€/sow**		**-95.22**
Building costs	€/sow	180.42	250.69
Operating result a.l.	**€/sow**	**-37.13**	**-234.23**

a.l .= after liquid manure costs, dcfp = direct cost-free performance, dlcfp = direct and labor cost-free performance
Source: calculations according to AGRI BENCHMARK (2016)

Scenario 2

In Scenario 2, the increase in the available space in the waiting area leads to a reduction in the number of sows by 43, 64 and 127 (Table 4). With 10 % additional space, the direct and labor cost-free performance reduced by liquid manure costs, proportionately to the total piglet production, is 15,191.53 € (reduction by 42.55 €/sow or 1.53 €/ piglet). With 20 % additional space allowance, taking into account the labor costs, a difference to the baseline scenario of -18,410.64 or -54.79 €/sow (or -1.96 €/piglet) is calculated. 40 % additional space allowance results in comparison to the baseline situation, to a reduction of the direct and labor cost-free performance by -36.468,00 € (-133.58 €/ sow or -4.79 €/piglet). The sow herd size reduction does not incur additional building costs. However, the building costs increase per sow, as the fixed costs are distributed over fewer animals - at 10 % by 21.73 €, 20 % by 34.37 € and 40 % by 83.93 € per animal.

Table 4: Economic effects of additional space allowance in gestation barn

		10 % additional space	**20 % additional space**	**40 % additional space**
Sow/group	number	17	16	13
Sows	number	357 (Δ 43)	336 (Δ 64)	273 (Δ 127)
Dcfp difference a.l.	€/year	-15,191.53	-22,610.64	-44,868.00
Reduction dcfp/sow	**€/year**	**45.20**	**71.47**	**174.56**
Labor costs	€/sow	235.29	237.50	276.92
Dlcfp difference a.l.	€/year	-15,191.53	-18,410.64	-36,468.00
Reduction dlcfp/sow	€/sow	42.55	54.79	133.58
Building costs	**€/sow**	**202.15**	**214.79**	**264.35**

Δ = change sow herd size (number), a.l. = after liquid manure costs, dcfp = direct cost-free performance,
dlcfp = direct and labor cost-free performance, Source: own calculations

By increasing the available space in the piglet rearing area, the number of animals per pen, which was previously 38, is reduced by four, seven or eleven animals (Table 5). With 5.98 rearing periods, 10,369 piglets per year can still be stabled with 10 % additional space. Similarly, with 20 % and 40 % additional space, 9,454 or 8,234 piglets are possible. Conversely, conclusions can be drawn from this with regard to the maximum possible number of sows, which is based on the number of weaned piglets that are subsequently housed in the piglet fattening barn. The sow herd size is 362, 330 or 287 animals depending on the extent of the additional space. The difference in the direct cost-free performance after liquid manure costs with 10 % additional space amounts to -13,425.07 € (-37.09 €/sow), with 20 % additional space -24,730.39 € (74.94 €/sow) and with 40 % additional space -39,921.92 € (-139.10 €/sow). After deducting the labor costs, a reduction of direct and labor cost-free performance at 10 % additional space results to 37.09 €/sow and year (-1.33 €/piglet), with 20 % additional space -62.21 €/sow and year (2.23 €/piglet) and 40 % additional space -109.83 €/sow and year (-3.94 €/piglet). By reducing the sow herd size, the building costs per piglet also increase. In the option «10 % additional space» the fixed costs increase by 0.68 €/piglet (18.94 €/sow), in 20 % by 1.37 €/piglet (38.27 €/sow) and at 40 % around 2.55 €/piglet (71.04 €/sow). The total operating result of piglet production is thus 78.11 €/sow, 107.22 €/sow or -161.58 €/sow.

Table 5: Economic effects of additional space allowance in piglet rearing barn

		10 % additional space	20 % additional space	40 % additional space
Pen size	m^2/piglet	0.385	0.42	0.49
Piglets/pen allowed	number	34 (Δ 4)	31 (Δ 7)	27 (Δ 11)
Piglet/year max.	number	10,369	9,454	8,234
Sow herd size max.	number	362 (Δ 38)	330 (Δ 70)	287 (Δ 113)
Dcfp difference a.l.	€/year	-13,425.07	-24,730.39	-39,921.92
Reduction dcfp/sow	**€/sow**	**37.09**	**74.94**	**139.10**
Labor costs	€/sow	232.04	241.82	263.41
Dlcfp difference a.l.	€/year	-13,425.07	-20,530.39	-31,521.92
Reduction dlcfp /sow	**€/sow**	**37.09**	**62.21**	**109.83**
Building costs	€/sow	199.36	218.69	251.46
Operating result	**€/sow**	**-78.11**	**-107.22**	**-161.58**

Δ = change sow herd size (number), a.l.= after liquid manure costs, dcfp= direct cost-free performance, dlcfp= direct and labor cost-free performance, Source: own calculations..

In pig fattening, there is a reduction in livestock by two, four or six animals per pen (Table 6) or by 420, 840 or 1,260 animals in total as space allowance is increased.

Table 6: Economic effects of additional space allowance in pig fattening

		10 % additional space	20 % additional space	40 % additional space
Pen size	m^2/pig	0.825	0.90	1.05
Pigs/pen allowed	number	17	15	13
Reduction/pen	number	-2	-4	-6
Places	number	3,570	3,150	2,730
Dcfp loss	€/pen	-180.24	360.48	540.72
Reduction of pigs	number	-420	-840	-1,260
Dcfp difference	€/year	37,850.40	75,700.80	113,551.20
Reduction dcfp	**€/FP**	**10.60**	**24.03**	**41.59**
Dcfp difference a.l.	€/year	35,399.70	70,799.40	106,199.10
Reduction dcfp a.l.	**€/FP**	**9.92**	**22.48**	**38.90**
Labor costs	€/FP	17.60	18.95	20.72
Dlcfp difference a.l.	€/year	35,399.70	67,657.28	99,914.85
Reduction dlcfp a.l.	€/FP	9.92	21.48	36.60
Building costs	€/FP	21.08	23.89	27.56
Operating result	**€/FP**	**45.60**	**44.44**	**36.00**

a.l.= after liquid manure costs, dcfp= direct cost-free performance, dlcfp= direct and labor cost-free performance, FP= fattening place, Source: own calculations.

The difference of the direct cost-free performance to the baseline scenario with 10 % additional space is a total of 37,850.40 € or -10.60 € per remaining fattening place. Accordingly, with 20 % additional space, a reduction in the direct cost-free performance of a total of 75,700.80 € or 24.03 €/fattening place is expected, as well as a with 40 % additional space an increase in the amount of -113,551.20 €/year or 41.59 €/fattening place (Table 6). After deduction of the liquid manure costs from the direct cost-free performance, there are additional costs per fattening place between 9.92 € and 38.90 €. If the labor costs are also taken into account, the additional costs will remain the same with 10 % additional space, while with 20 % or 40 % additional space they will decrease to 21.48 €/fattening place and 36.60 €/fattening place, respectively. Building costs increase from 18.86 € to 21.08 €/fattening place (10 % additional space), 23.89 €/fattening place (20 % additional space) and 27.56 €/fattening place (40 % additional space) due to the lower number of fattening places. The operating result is reduced with 10 % additional space to 45.60 €/fattening place, 44.44 €/fattening place (20 % additional space) and 36.00 €/fattening place (40 % additional space).

Scenario 3

Table 7 shows the effects of additional roughage feed via the DWT in the waiting area or over the racks in piglet rearing and pig fattening areas (Scenario 3). In the gestation barn the costs amount to 155.60 €/pen and year respectively 4.28 €/sow and 15.3 ct/piglet. In the piglet rearing area there are costs of 57.35 €/pen. In relation to each sow, this results in additional costs of 7.31 € (26.2 cent/piglet).

Tabelle 7: Economic effects of additional roughage feed in the waiting area or piglet rearing and pig fattening areas

Roughage	Waiting area	155,60 €/pen	€/sow/year	4.28	€/piglet	0.153
	Piglet rearing	57,35 €/pen	€/sow/year	7.31	€/piglet	0.262
	Pig fattening	63,65 €/pen	€/FP	1.20	€/kg slaughter weight	0.012
	Waiting area and piglet rearing		€/sow/year	11.59	€/piglet	0.415
	Piglet rearing and pig fattening		€/FP	1.46	€/kg slaughter weight	0.015
	Waiting area, piglet rearing and pig fattening		€/FP	1.61	€/kg slaughter weight	0.017

FP= fattening place, Source: own calculations.

Overall, the effort over the entire piglet production results in 11.59 € per sow or 41.5 cent per piglet. In the pig fattening there are costs resulting from the roughage feed to the amount of 63.65 €/pen and year. The costs per fattening pig are 1.20 € or 1.2 cent per kg slaughter weight. If the roughage feed is carried out both in the piglet rearing and in the pig fattening areas, costs per fattening pig amount to 1.46 €. With additional roughage feed in the waiting area, the costs increase to 1.61 €/fattening pig.

Discussion

The calculations for the exemplary farm show that the animal welfare measures considered; free-movement pen, additional space allowance and the additional roughage feeding as manipulable material, sometimes cause considerable additional costs. Without compensation for these additional costs, the economic viability and international competitiveness of German pig farmers is severely threatened. In particular, the decrease of livestock numbers in the scenario involving additional space or the remodeling of the farrowing barn causes a steep decline in the direct cost-free performance, which is only partly compensated by lower labor costs. Accordingly, the impact on the operating result is large and therefore also on recoverable income (Weiss 2013). The exemplary farm, with its size of sow herd, is well above the nationwide average of 227 sows (Statistisches Bundesamt 2017). For the region considered, the farm is also above the average (267.8 sows). As far as animal performance is concerned, the farm has an average of business branch evaluations from the management consultancy for cattle and pig farmers in the Hunte-Weser region over recent years (Urs Hunte Weser e.V. no year). The farm under consideration should therefore be characterized as a larger farm in the said region with average results. For an all-encompassing assessment of animal welfare measures, it is recommended to consider three farms - a medium-sized farm with average economic results, a farm of the type considered here, and a larger farm with very good economic results (Verhaagh et al. 2018).

On the basis of expert discussions, additional suckling piglet losses of 2.5 % in the free-movement pen were assumed in the calculations. The more expensive the piglets can be sold and the higher the number of live born piglets in the initial situation is, the more do resulting lost revenues from piglet sales have an impact since the leverage effect of increased losses in this case is greater. In addition, the building costs have a very strong effect on increasing the available space and thus the necessary livestock reduction: the fixed costs per animal increase, since the existing fixed costs are allocated over fewer animals. If no compensation payments are made, the direct cost-free performance will no longer be sufficient to cover the fixed costs from a certain point (Wahl 2015). In the production of piglets, the direct cost-free services in the years under consideration are anyway not sufficient to cover the fixed costs, so that a reduction in stocks would worsen this negative profit even further. It should be remembered that in a closed system the production costs per piglet are set. In the present case, market prices were used in order to be able to carry out a separate consideration of the branches.

Only the roughage feeding as manipulable material can be implemented relatively cheap. According to the calculations made here, the measure causes slightly lower costs than the 1.65 to 2 €/pig mentioned in the literature (Spandau 2015).

Any compensatory effects from the benefits of implementing animal welfare measures were not included in the calculations, as they are difficult to quantify at the present time. Possible positive effects include an increase in animal health, a reduction in the use of medication or an increase in daily weight gain. In addition, due to the use of the free-movement pen and associated increased freedom of movement, the sows may be more vital, inducing faster births and thus reduced mastitis metritis agalactia (MMA) vulnerability (Hoy 2013; Scholz et al. 2016). However, it is not yet certain that this will reduce the use of medication or the number of stillborn piglets. Conversely, it cannot be ruled out that deteriorations not taken into account here, such as daily gains, could also occur. In addition, in alternative farrowing systems, increased suckling pig losses are still to be expected (Heidinger et al. 2017). Such analyzes must be reserved for future research.

The calculations presented provide an important basis for providing recommendations for policy or actors along the value chain. The "Initiative Tierwohl" and animal welfare labels that have been established on the market have already developed systems that are based on voluntary participation and compensate for farmers' additional expenses. The German state animal welfare label, which is being set up at the moment, will soon be added. For these and similar systems, the calculations presented here provide benchmarks for measuring the compensation payments required for farmers. If politicians do decide to subsidize animal welfare measures, these results could also serve as a guideline. On the other hand, if higher standards are set by law, agricultural policy measures must compensate for the additional costs, so that a large proportion of farms do not have to leave production. In the past, a tightening of legislation has led to a significant reduction in farm numbers. In the period from 2010 to 2013, the introduction of group housing in the gestation barn caused a significant reduction of around 30 % in the number of sow-breeding farms in Germany (Imhäuser 2013). It also remains to be seen how the Magdeburg judgment and the associated conversions and reductions in the stock size in the service area will affect the number of sow-breeding farms in the future. The ban on anesthetic-free castration will also be a future challenge as implementable or cost-neutral solutions do not seem to exist here.

When considering these results, it is necessary, as is generally the case with all individual considerations, to refer to limitations. Thus, animal welfare measures that can be implemented quite simply and almost cost-neutrally on one farm can cause high costs on other farms with other requirements. Farms' structural conditions and their structural characteristics such as the size and location, have a major influence (Weiss 2013). In addition, when interpreting the results the influence of the assumptions made in each case, namely with regard to revenues, costs and biological performance, must be taken into account. In particular, fluctuating producer prices play a major role here. Last but not least, when converting conventional farrowing crates into free-movement pens in the farrowing barn, more complex construction measures can be expected than shown here. According to a survey by the Lower Saxony Chamber of Agriculture among 707 sow farmers in Lower Saxony, a large number of farms would have to make significant structural changes in the farrowing barn. Larger pens would have an influence on air flow and cutting off liquid manure channels. In particular, the liquid manure cellar seems to involve a very costly conversion. On 73 % of the farms surveyed, the compartments are only partial cellars, a restructuring would result in a redesign (Brüning 2018). In addition, where it is still possible under building permit law, extending barn buildings seems to be more favorable than dispensing direct cost-free performance by reducing animal herds, as in the present case.

Conclusions

Despite these limitations, the results presented are an important starting point for paving the way for a comprehensive economic impact assessment of higher animal welfare standards. The more observations of this kind that are carried out, the more detailed the picture becomes and the better the data basis is for assessing necessary compensatory payments to the farmers - if necessary also differentiated according to each situation. The aim should be to maintain the competitiveness of domestic livestock farming despite animal welfare-related additional expenses. In this respect, WBA (2015) demands for an improved political framework in the form of a reallocation of funds in the EU agricultural budget, the establishment of label concepts or the financing of measures to better inform consumers, are justified. At national level, measures to promote non-curative interventions on animals, and better coordination of public policies with industry initiatives such as the "Initiative Tierwohl" would also be very important. Overall, it is the task of politicians to shape the general conditions in such a way that competitiveness and profitability in production are reconciled with social demands for higher animal welfare standards. Last but not least, building law aspects should also be considered. It is also still important to work on scientific solutions that allow economic integration of higher standards of animal welfare into farms. Moreover, it is the task of science, to develop innovative concepts for animal husbandry in terms of a „stable of future" (Federal Ministry of Food and Agriculture 2017) as a base for science-based recommendations to policy makers. Finally, pig farmers must have the will to participate in innovative approaches. Previous studies have already shown that the willingness of farmers to participate in animal welfare programs has already increased significantly over recent years (Heise and Theuvsen 2016) against a background of very different attitudes towards animal welfare as well as sustainability standards in agriculture (Luhmann et al. 2016).

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